Executive Summary: Marine and Estuarine Shoreline Modification Issues

Ronald M. Thom and Gregory D. Williams
Battelle Marine Sciences Laboratory and Pacific Northwest National Laboratory

As part of the process outlined in Washington's *Statewide Strategy to Recover Salmon: Extinction is Not an Option* the Washington Departments of Fish and Wildlife, Ecology, and Transportation were charged to develop Aquatic Habitat Guidelines employing an integrated approach to marine, freshwater, and riparian habitat protection and restoration. Guidelines will be issued, as funding allows, in a series of manuals addressing many aspects of aquatic and riparian habitat protection and restoration.

This document is one of a series of white papers developed to provide a legitimate scientific and technical basis for developing Aquatic Habitat Guidelines. The white papers address the current understanding of impacts of development and land management activities on aquatic habitat, and potential mitigation for these impacts. Individual white papers will not necessarily result in a corresponding guidance document. Instead, guidance document development, addressing management and technical assistance needs, may incorporate information synthesized from one or more of the white papers.

The scope of work for each white paper requested a “comprehensive but not exhaustive” review of the peer-reviewed scientific literature, symposia literature, and technical (gray) literature, with an emphasis on the peer-reviewed literature. The reader of this report can therefore expect a broad review of the literature, which is current through late 2000. Several of the white papers also contain similar elements including the following sections: overview of the guidelines project, overview of the subject white paper, assessment of the state of knowledge, summary of existing guidance, recommendations for future guidance documents, glossary of technical terms, and bibliography.

This white paper addresses the impact of marine and estuarine shoreline modifications on naturally functioning fish and shellfish habitat in Washington State.

"Nearshore" marine habitats within Washington State span a continuum from upland to subtidal areas, and are defined to encompass the zone wherein direct functional interactions (e.g., sediment supply, primary production and export) occur between upland and marine habitats. Marine shorelines in Washington state can be grouped into three distinct regions: the shores of the inland coastal waters of Puget Sound and the Strait of Juan de Fuca; the outer coast fronting the Pacific Ocean; and the shores of outer coast estuaries. Within these regions, estuarine and nearshore marine habitats can take many forms, including eelgrass (especially *Zostera marina*) meadows, kelp forests, sand and mudflats, tidal marshes, river mouths and deltas, sand spits,

beach and backshore areas, banks and bluffs, and marine riparian areas. Broadscale patterns in Washington state's saltwater shoreline habitats have recently (1995-2000) been characterized under the Washington Department of Natural Resources ShoreZone mapping system that characterizes important physical, biotic, and anthropogenic features that can be considered indicators of ecosystem health. However, longterm monitoring databases and historic inventories are generally inadequate to assess and evaluate most nearshore habitat and resource trends in Washington State.

Human shoreline modifications in the region are commonly designed and built to dissipate wave energy, maintain navigation channels, control shoreline erosion, repair storm damage, protect from flooding, store or accumulate sediment, and promote commercial or recreational activity. General descriptions of these structures are as follows: 1) breakwaters and jetties that project into subtidal areas and are designed to dissipate wave energy, protect backshore areas, and direct tidal flow; 2) shoreline armoring or stabilization methods that include bulkheads, revetments, seawalls, groins, ramps, beach nourishment, and biotechnical approaches; and 3) tide gates, sewer outfalls, and artificial reefs that provide for a variety of other human needs (e.g., farmland creation, runoff and waste conveyance, and fishing and diving opportunities). Nearshore and estuarine resources of Washington State have been severely impacted by these shoreline modifications, which are particularly prevalent in the most populated areas of Washington State. Over 29% of Puget Sound's shoreline are stabilized by structures, with 1.7 miles of Puget Sound shoreline being newly armored each year. In King County alone, recent surveys have shown that armoring comprises 75-87% of the coastline.

Washington State's nearshore ecosystem plays a critical role in support of a wide variety of biological resources, many of which are commercially, culturally, aesthetically, and recreationally important to the people of the region. Nearshore habitats perform a variety of important functions within the ecosystem and support the life history and ecology of many species. For example, the nearshore foodweb is based upon detritus produced by plants (marine algae, estuarine and saltmarsh vascular plants, and especially eelgrass) that grow in highly productive shallow water habitats. Furthermore, shallow estuarine and nearshore habitats are structurally complex (e.g., submerged aquatic vegetation and large woody debris) and dynamic. As such, they are nursery areas for juvenile salmonids and other highly visible species (e.g., forage fishes, rockfishes, birds, and invertebrates) because they provide food, refuge from predators, spawning habitats, and a transition zone to physiologically adapt to salt water existence. All juvenile salmon move along the shallows of estuaries and nearshore areas during their outmigration to the sea, and may be found in these habitats throughout the year depending on species, stock, and life history stage.

Two complementary approaches are usually combined to interpret the ecological impacts of structural shoreline modification to the functionality of estuarine and nearshore marine habitats: 1) a conceptual approach involving inferences based on an informed understanding of the ecosystem and its processes, and 2) a direct approach that documents cause-and-effect through biological study. In general, most of our current understanding is based on a conceptual approach because relatively little controlled research has been directed at documenting and

understanding the functional impacts of shoreline modifications to biological resources. Few studies have applied rigorous, hypothesis-based testing that confirms these impacts.

The conceptual approach assumes that shoreline modifications will exert effects at varying degrees on an ecosystem's controlling factors. Controlling factors are physical processes or environmental conditions that control local habitat structure and composition (e.g., vegetation, and substrate), including where habitat occurs and how much is present. In turn, habitat structure is linked to support processes, such as shading or cover, which are linked to ecological functions. Thus, impacts that affect controlling factors within an ecosystem will be reflected in changes to habitat structure, and will ultimately be manifested as changes to functions supported by the habitat. The effect at the functional level depends upon the level of disturbance and the relative sensitivity of the habitat to the disturbance. While far more work is needed to quantify the fundamental relationships between habitat conditions and controlling factors for the nearshore environment in Washington State, a preponderance of inferential evidence exists to link the effects of shoreline modifications to changes in nearshore biological functions.

Besides simplifying shorelines and reducing intertidal habitat area, shoreline modifications have direct effects on nearshore processes and the ecology of nearshore dependent species by reducing the area of shallow water habitat and its functional attributes. The primary mechanism of these effects is manifested through chronic changes in regional hydrology (e.g., altered wave energy and current patterns, obstruction of littoral drift and longshore sediment transport, and altered fluctuations of temperature, salinity, and water levels), as well as direct impacts on structural aspects of the site (e.g., permanent change of habitat, reflective turbulence, turbidity). In turn, shoreline modifications may impede the movement of species; alter substrate characteristics; change primary production, food web dynamics, and predator-prey interactions; and modify residence patterns that affect nursery or physiological transition functions. The design and location of shoreline structures can significantly affect relative impacts to nearshore biological resources. Furthermore, effects appear to be highly site, habitat, and scale-dependent, and depend upon the level of disturbance and the relative sensitivity of the habitat to the disturbance; it is difficult to accurately generalize a finding from one site to another site. While the adverse environmental impacts associated with a single shoreline stabilization structure may not always be great, there is a growing concern regarding the cumulative ecological effects of shoreline armoring within a landscape. From a landscape perspective, the cumulative impact of losses in connectivity between natural nearshore and estuarine habitats remains difficult to measure and untested.

A broad array of habitat protection and mitigation techniques exist that can minimize or limit the impact of shoreline modifications to estuarine and nearshore marine areas. Actions that can mitigate these impacts include avoidance (i.e., no shoreline modification), minimization of impacts by using alternative structural modification strategies (e.g., "soft" approaches that involve natural materials that can deform and adjust over time to changing shoreline conditions), land use management (e.g., building setbacks, storm and groundwater management, and vegetation management), and compensation via restoration of other degraded sites. There is a need to systematically examine the long-term success or relative benefits these approaches accrue as habitat to nearshore species. Properly designed estuarine restoration projects,

including shoreline structure removal, may return a habitat to a close approximation of its condition prior to disturbance. However, restoration actions vary widely in their "success" rate. The potential for success varies depending on the degree of disturbance that exists at the site and within the landscape where the restoration site is located. Measures for protecting and restoring critical shoreline and estuarine habitats should incorporate principles of landscape connectivity and extend to activities outside of their conveniently defined boundaries.

While our review of the available research literature shows that explicit documentation is limited, adequate evidence exists to suggest that shoreline modifications have a high potential for severely impacting nearshore biological resources in Washington State. The following recommendations are offered as part of a comprehensive strategy to better protect, restore, and enhance associated nearshore and estuarine habitats in the region:

- A thorough physical assessment on a site-specific basis must be carried out to fully understand and document the potential direct, indirect and cumulative impacts prior to allowance of any shoreline modifications
- Protect and restore sensitive marine nearshore and estuarine habitat and ecological functions by avoiding shoreline structural modifications altogether.
- Where new shoreline modifications must occur, impacts should be minimized by pursuing alternative techniques (e.g., beach nourishment) and placement strategies
- Phased restoration of natural processes and ecological functions should be achieved through the strategic removal of unnecessary shoreline structures, especially in areas with particularly high rates of shoreline armoring and habitat structural modification.
- Restoration projects are uncertain and must be planned and evaluated carefully.
- Existing documents (Dethier et al. 1990, Simenstad et al. 1991a) should be used to provide a solid scientific basis for assessing the potential effects of changes caused by shoreline modifications and restoration on habitats and resources.
- Existing baseline inventories (e.g., WDNR 2000, ShoreZone Inventory database) should be used for determining habitat trends, locating critical areas for protection or restoration, and identifying nearshore ecosystems most at risk to cumulative impacts.
- A comprehensive research program is needed immediately to provide critical empirical data required to understand the relationships between placement of artificial structures in the marine environment and direct, indirect, and cumulative physical and biological changes that will occur on a local and larger scale.